# BIOMECHANICAL PROBLEMS OF THE LUMBAR SPINE

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If a man drops down from a relatively low height, landing on his feet with legs straight, he easily gets a fracture of the os calci. It is a rule always to examine the back, because this fracture is often combined with fracture of vertebrae. If both os calcii are fractured there should be an x-ray examination of the spinal column. On the other hand, if the man falls on his gluteal region and is unfortunate enough to get a fracture, it is a fracture of the vertebral column, except three per cent which are fractures of the pelvic ring. The vertebral column is from a mechanical point of view a very vulnerable part of the body. From a clinical point of view, we often hear patients declare that they feel something breaks in their back after a dynamic or static stress. The x-rays are negative; still something must have happened, but what?

To get an answer to this question I have done experimental investigations on specimens consisting of two vertebrae with the intervening disk, or three vertebrae with the intervening disks, from a great number of individuals. I have used both static and dynamic stress. The inner part of the disk has been visualized by diskography. The course was followed with x-ray films with 48 pictures/sec and with pressure curves.

I found that there was a great biological variation on the breaking-point. It was statistically clear that the breaking-point on individuals over 60 years old was much lower than in younger groups. The average values in the group over 60 years old was 425 kp. In individuals under 40 years old the breaking-point varied between 500- and 1,100 kp, with an average value 790 kp. In one-third of the specimens I get fracture of the vertebral end-plates. These fractures can be divided into three different types:

a. fractures centrally in the end-plate

b. fracture of the end-plate situated so far peripherally that a corner of the vertebral body is torn loose

c. fissure extending across the entire end-plate which, when deepened to involve the whole vertebral body, divides it into two parts. This is the first stadium of the common compression fractures.

As an accessory finding I can mention that the osteophytes are very fragile and they fracture even for 100 to 150 kp. To get a better understanding of these fractures I have examined the resistance both on the whole vertebral body and on different parts of the end-plate. The resistance of the body varied between 400 and 1,100 kp. I have also analysed the disk from different points of view. The result is this:

In a newborn child, the nucleus is semigelatinous and contains 90 per cent solution. Normally it desiccates with age, and at 70 years of age the nucleus contains only

65 per cent solution. This is a normal change, depending on age, called degeneration. In a young individual with a high amount of liquid, the nucleus takes three-fourths of the weight on the disk. The weakest walls in this room are the end-plates. With increasing force the intradiskal pressure increases and finally the end-plate fractures. This is demonstrated both analytically and experimentally. You never get a hernia by stress from a disk in this condition. With a dryer disk the pressure is transferred more and more by the annulus, and when the breaking-point is reached, that part of the vertebral body which is involved by the Sharpeys fibres fractures. Fracture in the frontal part is common and easy to diagnose, but in the dorsal part it is difficult to demonstrate on the x-ray film because of the kidney shape of the vertebral body.

A usual question is: What is the real strength of the vertebral arches and the articular process? In the older literature they say that this is the strongest part of the vertebrae. Now we know that this part only takes 20 per cent of the weight.

We can say that mechanically the lumbar vertebrae can stand a static stress of 800 kp or a dynamic stress during 0.006 sec of 1,300 kp. These values are quite low and something else must be involved in the weightbearing.

If you take a look at gorillas, you will see that they are heavy and very strong. The stress on their lumbar vertebrae must be high. The diameter of their vertebral body is less than that of the human. Fifty-five Swedish airforcemen have been catapulted, and of those 13 have gotten fractures mainly of the type I have shown from my experiments. The acceleration during 0.05 sec is 22 g, which means about 800 kp. This is near the breaking-point, but only 25 per cent get fractures. This must depend on muscle power, which has a much larger significance than we had believed earlier. All of you who are sailing know how important the guy-rope is for the mast, and I am absolutely convinced that the muscles are of the same great significance for the vertebral column. Erector trunci keeps the back upright but the abdominal muscles take part in the weightbearing of the body. If you have a long, thin balloon and increase the pressure, it will become stiff; in the same way you can keep the body upright by increasing the intra-abdominal pressure. Bartelink, and later Morris, Lucas, and Bressler, have demonstrated through EMG and by measuring the intra-abdominal and intra-thoracal pressure how these structures contribute to weightbearing. These investigations are just starting, and I am sure that they will reveal several pieces in the great and difficult biomechanical puzzle.

Other research tasks which still are unsolved relate to the resistance of the ligaments. I especially think of the interspinos-ligament. Ruptures in this ligament arise from dynamic forces, and produce back pain. When it heals with connective tissue—this being a poor tissue—it easily breaks again.

An interesting problem is the rotation of the lumbar spine. The intervertebral joints admit movement in two planes, but they limit rotation in the highest degree; otherwise the disk would be destroyed by torsion. The segment of movement in the lumbar spine can be compared to a universal joint. If you put a series of such universal joints together and have the whole series in a line, you can't rotate, but if you bend the whole series into an S-shape you can get a good deal of rotation. That is why we have kyfosis and lordosis. But what happens when you don't have the lordosis?

In conclusion may I emphasize that the spine is, from a mechanical and clinical point of view, a very weak part of the body, and therefore we must try to solve every problem related to it.